

WHAT IS CLAIMED IS:

1. A method of performing thermal imprint lithography of a surface of a workpiece for forming a pattern therein, comprising pre-heating said workpiece to a pre-selected elevated temperature prior to inserting said workpiece in a stamping/imprinting tool for performing said thermal imprint lithography, whereby the interval for thermal cycling of said stamping/imprinting tool between higher and lower temperatures is eliminated or at least reduced.  
5
2. The method according to claim 1, wherein the temperature of said stamping/imprinting tool is maintained substantially constant at a pre-selected temperature lower than the pre-selected elevated temperature of the pre-heated workpiece.
3. The method according to claim 2, comprising the steps of:
  - (a) providing a said stamping/imprinting tool comprising a stamper/imprinter having an imprinting surface including a negative image of said pattern to be formed in said workpiece surface;
  - 5 (b) maintaining said stamper/imprinter of said stamping/imprinting tool at a pre-selected first high temperature;
  - (c) providing a said workpiece having first, upper and second, lower surfaces;
  - (d) heating said workpiece to a pre-selected second high  
10 temperature greater than said pre-selected first high temperature;
  - (e) transferring the heated workpiece to said stamping/imprinting tool;
  - (f) urging said first, upper surface of said heated workpiece against said imprinting surface of the heated stamper/imprinter at a pre-selected high  
15 pressure sufficient to imprint said pattern in said first, upper surface;
  - (g) continuing said urging of said first, upper surface of said heated workpiece against said imprinting surface of said heated stamper/imprinter at

20 said pre-selected high pressure for a pre-selected interval, during which interval the temperature of said heated workpiece is lowered to said pre-selected first high temperature of said stamper/imprinter;

(h) separating the imprinted surface of said workpiece from said imprinting surface of said stamper/imprinter; and

(i) removing said workpiece from said stamping/imprinting tool.

4. The method according to claim 3, wherein:

step (c) comprises providing a said workpiece in the form of a flat, disk-shaped substrate for a hard disk recording medium, said first, upper surface of said substrate being coated with a layer of a thermoplastic material.

5. The method according to claim 4, wherein:

step (c) comprises providing a substrate comprising Al, an Al-based alloy, NiP-coated Al, glass, ceramic, or a glass-ceramic composite material.

6. The method according to claim 4, wherein:

step (a) comprises providing a stamping/imprinting tool including a stamper/imprinter having an imprinting surface comprising a negative image of a servo pattern to be formed in said first, upper surface of said workpiece.

7. The method according to claim 6, wherein:

step (a) comprises providing a stamper/imprinter having a Ni imprinting surface.

8. The method according to claim 7, wherein:

step (a) further comprises providing said Ni imprinting surface with a layer of a release agent.

9. The method according to claim 8, wherein:

step (a) comprises providing a stamper/imprinter having an imprinting surface coated with a layer of a fluorinated polyether compound.

10. The method according to claim 4, wherein:

step (b) comprises maintaining said stamper/imprinter at a pre-selected first high temperature close to a glass transition temperature  $T_g$  of said layer of thermoplastic material on said first, upper surface of said substrate;

5 step (d) comprises heating said workpiece to said pre-selected second high temperature which is greater than said pre-selected first high temperature of said stamper/imprinter and greater than the glass transition temperature  $T_g$  of said layer of thermoplastic material on said first, upper surface of said substrate; and

10 step (f) comprises commencing said urging of said heated substrate against said imprinting surface of the heated stamper/imprinter when the temperature of said heated substrate is above said glass transition temperature  $T_g$  of said layer of thermoplastic material on said first, upper surface of said substrate.

11. The method according to claim 10, wherein:

step (c) comprises providing a substrate including a first, upper surface coated with a layer of a polymethyl methacrylate (PMMA) thermoplastic material having a glass transition temperature of about 105 °C;

5 step (b) comprises maintaining said stamper/imprinter at a pre-selected first high temperature of about 120 °C; and

step (d) comprises heating said workpiece to a said pre-selected second high temperature of about 200 °C.

12. The method according to claim 3, wherein:

step (a) comprises providing a said stamping/imprinting tool including first, upper and second, lower mounting means for respectively mounting thereon said stamper/imprinter and said workpiece, each of said first and

5 second mounting means including heating means for maintaining the respective mounting means at said pre-selected first temperature; and

step (e) comprises placing said second, upper surface of said heated workpiece in overlying relation to said second, lower mounting means.

13. The method according to claim 12, wherein:

step (c) comprises providing a workpiece having a thermally insulating spacer in contact with said second, lower surface thereof, whereby the rate of temperature reduction of said heated workpiece from the pre-selected second, 5 higher temperature established in step (d) is lowered relative to the rate of temperature reduction obtained in the absence of said thermally insulating spacer.

14. The method according to claim 13, wherein:

step (c) comprises providing said workpiece with a thermally insulating spacer comprised of a glass material.

15. A method of forming a desired pattern in a surface of a substrate for a hard disk recording medium, comprising the steps of:

(a) providing a substrate in the form of a flat disk having first, upper and second, lower surfaces, said first, upper surface being coated with a 5 layer of a thermoplastic material;

(b) providing a stamping/imprinting tool including a stamper/imprinter having an imprinting surface comprising a negative image of said pattern to be formed in said surface of said substrate;

(c) maintaining said stamper/imprinter of said stamping/imprinting 10 tool at a pre-selected first high temperature close to a glass transition temperature  $T_g$  of said layer of thermoplastic material on said first, upper surface of said substrate;

(d) heating said substrate to a pre-selected second high temperature which is greater than said pre-selected first high temperature of said 15 stamper/imprinter and greater than said glass transition temperature  $T_g$  of said layer of thermoplastic material on said first, upper surface of said substrate;

(e) transferring the heated substrate to said stamping/imprinting tool;

(f) urging said heated substrate against said imprinting surface of 20 the heated stamper/imprinter at a pre-selected high pressure sufficient to imprint said pattern in said layer of thermoplastic material on said first, upper

surface of said substrate, wherein the temperature of said substrate when said urging of said heated substrate against said imprinting surface of the heated stamper/imprinter commences is above said glass transition temperature  $T_g$  of  
25 said layer of thermoplastic material on said first, upper surface of said substrate;

30 (g) continuing said urging of said heated substrate against said imprinting surface of said heated stamper/imprinter at said pre-selected high pressure for a pre-selected interval, during which interval the temperature of said heated substrate is lowered to said pre-selected first high temperature of said stamper/imprinter;

35 (h) separating said substrate with said imprinted layer of thermoplastic material thereon from said imprinting surface of said stamper/imprinter; and

35 (i) removing said substrate from said stamping/imprinting tool.

16. The method according to claim 15, wherein:

5 step (b) comprises providing said stamping/imprinting tool as including first, upper and second, lower mounting means for respectively mounting thereon said stamper/imprinter and said substrate, each of said first and second mounting means including heating means for maintaining the respective mounting means at said pre-selected first temperature; and

step (e) comprises placing said second, upper surface of said heated substrate in overlying relation to said second, lower mounting means.

17. The method according to claim 16, wherein:

5 step (a) comprises providing a substrate having a thermally insulating spacer in contact with said second, lower surface thereof, whereby the rate of temperature reduction of said heated substrate from the pre-selected second, higher temperature established in step (d) is lowered relative to the rate of temperature reduction obtained in the absence of said thermally insulating spacer.

18. The method according to claim 15, wherein:

step (a) comprises providing a substrate comprising Al, an Al-based alloy, NiP-coated Al, glass, ceramic, or a glass-ceramic composite material, said substrate comprising a first, upper surface coated with a layer of a

5 polymethyl methacrylate (PMMA) thermoplastic material having a glass transition temperature of about 105 °C;

step (b) comprises providing a stamping/imprinting tool comprising a stamper/imprinter having an imprinting surface including a negative image of a servo pattern to be formed in said thermoplastic PMMA layer on said first,

10 upper surface of said substrate;

step (c) comprises maintaining said stamper/imprinter at a pre-selected first high temperature of about 120 °C; and

step (d) comprises heating said workpiece to a said pre-selected second high temperature of about 200 °C.

19. The method according to claim 18, wherein:

step (b) comprises providing a stamper/imprinter having a Ni imprinting surface, said Ni imprinting surface including thereon a layer of a release agent.

20. The method according to claim 15, further comprising the steps of:

(j) forming said desired pattern in said first, upper surface of said substrate by a process comprising selective removal of substrate material,

5 utilizing said imprinted layer of thermoplastic material as a pattern-defining mask; and

(k) selectively removing said imprinted layer of thermoplastic material subsequent to performing step (j).